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EDITORIAL NOTES

AWAITING A LEAD

A FEW weeks ago, discussing the use of producer gas in place of petrol and heavy oil for motor transport, we asked to what use, and when, we were going to put the large amount of knowledge and experience which has been accumulated on this subject during the past five years—as far as experience goes, particularly during the past two years. We recalled that in November last the Secretary for Mines invited the Henley Committee to examine the sources of fuel for producer gas vehicles, to estimate the quantities which could be made available at once, and to report on the measures that would be required to increase the supplies if it was deemed necessary. We think it may well prove desirable to increase such supplies. As a matter of fact there are to-day quite a large number of vehicles on the road operating on producer gas and giving service which does not compare unfavourably with that given by petrol. It would be easily possible to produce in large quantities fuel suitable for gas producers. Activated coke made in vertical retorts satisfies the requirements, and we would emphasize again that the effects of activation on the production of smokeless fuel for the domestic firegrate add to the attraction of the process. Granted adequate coal supplies and availability of plant the Gas Industry would technically have no difficulty in fulfilling the demand for producer fuel of the type envisaged. We think it likely that events will prove the desirability of continuing to operate motor vehicles on home produced solid fuel at any rate for some considerable time after the war is over. Everything seems to point to this.

Last Thursday the Secretary for Petroleum announced that for private motoring the value of the basic petrol ration coupons for May and June will be halved, that from July 1 the basic ration itself will cease to exist, and that supplementary petrol allowances will be further reduced beginning next month. Private motoring is not the concern of this note, nor can we imagine that producer gas can play any substantial part in such motoring; but the announcement has an obvious bearing on the use of producer gas for commercial vehicles, and the fact stands out that producer gas could be employed in large quantities for heavy duty work and long distance transport. It has been suggested that a fifth of the commercial transport of the country could reasonably be operated on producer gas. This would create a demand for suitable coke of something in the neighbourhood of 2,000,000 tons a year.

The day previous to the Secretary for Petroleum's announcement of petrol cuts there was a debate on producer gas in the House of Lords, when its use on the largest possible scale was warmly advocated by a number of speakers on a variety of grounds, notably the aggravation of the oil position by events in the Far East and the vital need for reducing the strain on shipping. The reply of the Minister of War Transport to this advocacy did not strike us as being particularly satisfying. True, he said that he would do anything he could to encourage any system other than petrol which would drive vehicles satisfactorily, and he gave assurance that there would be no dilatoriness on the part of the Government; but we think he gave disproportionate weight to the negative aspect, to the difficulties of the proposition. The immediate point at issue, we suggest, is not whether producer gas is inferior to petrol and heavy oil for the purpose, but whether it can be used in place of imported oil fuel—and surely this has been proved. Any comparison based on peacetime considerations is merely a theoretical polemic when we are faced with present conditions and those likely to obtain in the near future. In producer-driven vehicles, as compared with petrol-driven, observed the Minister of War Transport, there is loss of power, loss of pay-load, and increased cost of maintenance. Producer vehicles, he added, also mean the conversion of "common" fuel and other materials which are in great demand. Therefore, "a sensible time must be allowed for the present road trials to show up the advantages and imperfections before anything like a great extension can take place. We must not do anything to reduce the efficiency of our road services or to interfere with the flow of goods."

What, we would ask, does the Minister of War Transport consider at this stage of the war a "sensible" time to allow to show up the advantages and imperfections? The Government has been investigating the problem since 1937. Does it want a further five years' study on the relative merits of imported oil and producer gas or other alternatives? Is it satisfied that it will continue to enjoy sufficient imports of oil to ensure the "flow of goods" commensurate with ever-increasing war production-effort and coming attack and defence? If imported oil is not to be had in the requisite quantity, are commercial vehicles to be allowed to remain idle pending further study of alternative fuels? It seems to us that the current position is sufficiently grave to warrant decision rather than continued discussion on the relative merits of imported oil and producer gas. If the Government damns producer gas for commercial transport with faint praise, though requesting further investigation, we shall accept the situation not only with good grace, but with very real joy, for we shall realize that such an attitude could only imply that the Government is happy and well content about oil supplies, and that our own forebodings are mere barkings up the wrong tree. We wonder what the recommendations of the Henley Committee will be on the matter; its report, we are told, is hoped for in about a week's time. We wonder what the Government's reaction will be to it.

LESS GAS—GREATER OUTPUT

MUCH good, we think, should come of the scheme of free training in fuel efficiency organized, at the suggestion of the Fuel Efficiency Committee, by the Mines Department in co-operation with the Board of Education. Enrolments for the classes already established show clearly the real need for training of the sort in order to obtain the best results from the country's supplies of fuel. We learn with gratification that the response from industry has been almost overwhelming and that there has been no hesitation in largely extending the scheme. The war effort should benefit greatly by it, for the amount of fuel needlessly employed must in the aggregate be enormous. The Gas Industry's chief concern is wastage due to lack of care in the practical use of furnaces, and wastage due to incorrect combustion of gas in the absence of technical control.

It was on this wastage that the Director-General of Gas Supply concentrated his attention immediately on his appointment, and already as a result of the work of the "gas chasers" which he advocated, and to which reference has been made in these columns, millions of therms of gas have been saved in the matter of a few months. Some particulars of the results of the work of "gas chasers" in the Sheffield area were given by Dr. H. A. Fells at a meeting in Sheffield last month held at the request of the Mines Department. We published a report of the meeting, which was one of the series convened in collaboration with the leading scientific and technical bodies concerned with the production and utilization of all types of fuel and energy, in the "JOURNAL" last week. On one furnace, Dr. Fells explained, gas consumption was reduced by 20%, while output

was increased by 30%. In another instance, by concentrating output in five furnaces instead of six, a saving in gas was at once effected of 40% per unit of steel. Results of this nature should excite the interest of industrialists and rivet their attention on the efficient use of fuel supplies.

Under peacetime conditions fuel costs represented in many instances only a small proportion of the total cost of manufacture, and it was perhaps understandable that on the onslaught of war manufacturers were prepared to sacrifice cost in order to maintain high rates of output. Now, however, it must be abundantly clear that the point at issue is not the cost but the availability of the fuel. Where this point has been fully grasped and where action has been taken it has been shown beyond argument that higher rates of production can be achieved by the use of less gas—*i.e.*, when the gas is employed at its best efficiency. Obviously the more widespread and speedier the steps taken to ensure this—and the steps involve no undue difficulty—the better. The Gas Industry is out to help industrialists in the matter ; it has available any amount of sound advice and information which can be put to immediate use.

KINEMATIC VISCOSITY

THE question of gas quality in relation to the performance of gas at the consumer's burner has for a long time been foremost in Gas Industry thought and research, but never more so, we think, than at the present time. Many years ago it was reasonably established that for most gas-using purposes one B.Th.U. is as good as another. This conclusion, of course, was drawn on technical grounds and without reference to cost. For many years, too, it has been recognized that among the composite factors of gas quality calorific value is one, but only one, and from the point of view of performance not necessarily the most important one, though all-important as a basis of charge. At the moment we have a small Institution Committee asking for and sifting evidence in order to make recommendations on the most suitable quality of gas from all aspects for supply to consumers in Great Britain, and lately our pages have recorded much discussion on calorific value standards. In our issue to-day we publish the first part of an abstract—the Author's own abstract by the way—of a Paper by Mr. Arthur Coe to the Scottish Junior Gas Association, the major part of which contribution dealt with this question of gas quality. Now the Author's contention is easy enough to state—that the consumer's burner must be the criterion on which to base any standardization of gas quality, that one must work back from this to determine the way gas should be made. His arguments are not easy to follow or assess except by a physicist, and it will be noted that he takes the bunsen burner as the basis, while the future may well see a far greater usage of non-aerated flame burners.

Mr. Coe, it will be seen, pins his faith to "kinematic viscosity" as being the all-important measure of gas quality. "Kinematic viscosity" is the absolute viscosity of a gas divided by its density, and the Author says of it: "The combustion characteristic of any combustible mixture of gases is its kinematic viscosity, just this and nothing more." He asks that an immediate concentrated effort to prove or disprove the hypothesis that kinematic viscosity is the measure of gas quality should be made, and that if the hypothesis is proved, then a standard kinematic viscosity should be adopted for the whole country.

In the years immediately preceding the war a great deal of research work was carried out on "combustion characteristics" by the Gas Industry, taking the performance of gas when burned in a bunsen burner as the criterion. "A.T.B." numbers were assuming significance, and investigations on similar lines in other countries had been closely examined and critically analyzed. Institution blue books on the research, which was a major item of the Industry's general research programme, had been published. It should not therefore, we suggest, be a matter of undue difficulty for those who have been engaged on this work for years to look into Mr. Coe's forthright championship of kinematic viscosity and report on the validity or otherwise of his contention. The Author explained that it was in 1938 that he first thought he had found an answer to what "quality" in coal gas means. Two years later he was "much more certain about it" and he made his views the subject of a private report to the Gas Research Board. He is now "as certain of the answer as anyone can be in a matter of this kind." His views being no longer in the nature of a private report, many in the Industry would doubtless desire some authoritative indication of their possible value. Perhaps the Gas Research Board have already formed an opinion the expression of which would not prove inimical to the war effort. If not, they might perhaps feel inclined to consider the point anew.

Wartime Poker

Essex housewives have no chips at stake in their new game of poker. Undaunted by the scarcity of matches and firewood, and staunch supporters of the save-paper campaign, they still manage to light their fires—and with far less trouble than formerly. The community-first, help your neighbour idea has found further expression in that County—this time in fire lighting without watching. Housewives there form their own voluntary fire lighting parties, the only appliance needed being a gas poker, the initial expense of which they are only too willing to share. The poker is used in turn and each player wins a game. There is no gamble whatever about it, and far from acquiring poker faces the ladies of Essex are noticeably developing expressions favourable to gas.

Personal

Mr. E. H. PAYTON has been elected Chairman of Drakes, Ltd., Halifax. Mr. Payton, prior to his retirement on Sept. 30, 1940, was Secretary of Baldwins, Ltd.

Letter to the Editor

Flow of Gas in Mains

DEAR SIR,—I have read with much interest the article by Dr. G. E. Foxwell entitled "Standards of Calorific Value for Gas" which appeared in your issue of Jan. 14 last.

I should like to refer to the section headed "Distribution Costs" wherein Dr. Foxwell discusses several formulæ for the calculation of gas flow in mains.

The Spitzglass formula is chosen in preference to that due to Pole because of the fact that it takes into account the changing value of the coefficient of friction (zeta) with changing diameters of pipe.

Now, Mr. Stephen Lacey has pointed out that the value of zeta varies not only with pipe diameter but also with velocity of flow, density, and viscosity.

It would therefore appear that Mr. Lacey's modification of the Chezy formula, where all these factors are taken into account, is much more accurate than either of the others.

Using Dr. Foxwell's data and calculating the flow by means of each of the three formulæ, the following results are obtained:

Assuming 10,000 yards of 10 in. main with a pressure drop of 3 in. W.G. and an s.g. of 0.45.

Poles' formula $Q = 1{,}350 \left(\frac{p.d^5}{s\,l}\right)^{\frac{1}{2}}$

$= \underline{11{,}000.}$

Spitzglass formula $Q = 3{,}550 \left(\frac{d^5}{1 + 3.6/d + 0.03d}\right)^{\frac{1}{2}} \left(\frac{P}{3\,S\,l}\right)^{\frac{1}{2}}$

$= \underline{13{,}000.}$

Lacey's formula $Q = 188 \left(\frac{p.d^5}{Z\,S\,L}\right)^{\frac{1}{2}}$

(where the value of "Z" is obtained from the graph published in the "GAS JOURNAL" Year Book)—

$= \underline{10{,}200.}$

In view of the above facts, I should be interested to hear Dr. Foxwell's reason for choosing the Spitzglass formula in preference to Lacey's

March 11, 1941. "ENQUIRING STUDENT."

National Gas Council

A Meeting of the Central Executive Board of the National Gas Council was held at Gas Industry House, 1, Grosvenor Place, S.W. 1, on March 10. In the absence of Sir David Milne-Watson, the Chair was taken by Mr. A. W. Smith.

Alderman Sir William Kay.—Before proceeding with the business of the meeting, members learnt with regret that the Treasurer of the Council, Alderman Sir William Kay, had met with an accident and was lying in hospital. It was understood, however, that he was making good progress, and the hope was expressed that his recovery would be speedy.

Coal.—A brief report was received on the general position. Complaints were made as to deterioration in the quality of coal being delivered to undertakings, and that the grading, cleaning, and washing left much to be desired. It was agreed that the attention of the Public Utilities Coal Committee should be drawn to these matters.

Appointment of Regional Liaison Officers of the Gas Directorate.—It was stated that a Memorandum had been circulated to the members of the Board, setting out an arrangement authorized by the President of the Board of Trade whereby the Director-General of Gas Supply was to appoint in each Regional Defence Area a Liaison Officer of the Gas Directorate to carry out a complete survey of gas undertakings. This work was not to cut across or interfere with the work of the Regional Gas Engineering Advisers, whose duties would be limited to meeting contingencies arising from enemy action. After discussion it was agreed to accede to the Board of Trade's request that the Memorandum should be circulated with a letter urging gas undertakings to give the Liaison Officers every assistance.

Reconstruction.—It was stated that an appeal had been received from Mr. W. H. Ansell, President of the Royal Institute of British Architects, in support of an Exhibition to be held in the first instance at the National Gallery, London, demonstrating the work of the Reconstruction Committee of the Royal Institute of British Architects, which was appointed in March, 1941. It was reported that the appeal had been addressed to organizations representative of building materials' manufacturers and distributors, and included among others the National Gas Council, the British Commercial Gas Association, the Society of British Gas Industries, the Association of Tar Distillers, and the British Electrical Development Association. A meeting had been called by the Royal Institute on March 6, at which Mr. Stephen Lacey had been present. He reported that a small committee had been set up to determine the allocation of cost among the various Associations represented.

It was agreed that the next meeting of the Board should take place on April 14 at 1.30 p.m.

Iron and Steel Distribution Scheme

The Ministry of Works and Buildings draws attention to the following points in connexion with the procedure announced in November, 1941, for simplifying the working of the Iron and Steel Distribution Scheme by the issue of bulk iron and steel authorizations for small orders of manufactured articles required primarily for the building industry.

The "small orders" arrangement applies only to orders for manufactured articles (or fitted and finished goods) containing in all 1 cwt. or less of iron and steel combined in each order, and does not apply to iron and steel in the forms listed in the First Schedule to the Control of Iron and Steel (No. 15) Order.

The manufactured articles for which the Ministry of Works and Buildings (Headquarters—A.S. 69) issues bulk authorizations of iron and steel to manufacturers for production for (*a*) small orders (all essential purposes other than exports) and/or (*b*) essential home civil trade (excluding work subject to licence under Regulation 56A) include stoves, grates, ranges, and cooking apparatus (solid fuel), oil heaters and cookers, cast iron hot water boilers (including gas-fired boilers used for central heating), radiators and radiator fittings, and other manufactured apparatus and accessories used in connexion with central heating installations, and unit heaters and convectors.

The **Meeting** of the Liquor Effluents Committee of The Institution of Gas Engineers which was fixed for March 20 has been postponed to March 27 at 12.15, Gas Industry House.

The **Minister of Works and Buildings** announces that, in consequence of improvements in the supply position, it has been possible to discontinue the procedure whereby supplies of aluminous cement could only be obtained by an application supported by a certificate from the appropriate Government Department or other authority. Supplies of the cement may accordingly now be ordered in the normal way through ordinary trade channels whenever its use is essential to expedite work of national importance. At the same time the need for economy in the use of aluminous cement continues, and its use should be restricted to the type of case referred to in the preceding paragraph. If difficulty should be experienced in obtaining supplies in such cases, particulars of the orders, and a statement of the justification for the use of the cement, should be furnished to the Director of Cement, Ministry of Works & Buildings, Lambeth Bridge House, London, S.E. 1, who will give every assistance possible.

Institution of Gas Engineers

The Council of The Institution of Gas Engineers met in London on March 10. There was a full attendance and the following were some of the matters dealt with:

Obituary.—The death since the last meeting of eight members of the Institution was reported, including Mr. Thomas Glover, C.B.E. (Norwich), President in 1908–1909, and Mr. T. H. Poulson (Stafford), a former member of Council.

79th Annual General Meeting.—Further details of the programme of the 79th Annual General Meeting—*e.g.*, titles and Authors of short Papers, place of meeting, &c.—were considered.

Officers, 1942–43.—Consideration was given to the nominations to be made by Council for election by ballot of corporate members, for the offices of President, Vice-Presidents, Honorary Secretary, and Auditors.

Affiliated District Gas Associations.—Reports were made by District Members of Council concerning the activities of the Affiliated District Gas Associations, and suggestions made by them were discussed.

Committees of Enquiry.—It was reported that the four Committees of Enquiry appointed by the Council to consider some of the questions arising from the Institution Symposium of June, 1941, are continuing to be very active and that more than one has reached the stage of drafting a report to the Council.

Post-War Planning Committee (British Gas Federation).—A general review was given of the progress made by the Post-War Planning Committee of the British Gas Federation.

Salaries of Gas Engineers.—The views of the affiliated District Gas Associations regarding action so far taken in the matter of scales of salaries of gas engineers were reported by District Members of Council and were fully discussed. There will be an early meeting of the Salaries Committee, upon which each District Association is represented, to consider in detail these and other relevant points and to report to the Council.

Accounts and Budgets.—The Accounts of the Institution for 1941 were considered and passed, subject to audit. It was agreed that the accounts revealed a continued healthy financial position of the Institution. Budgets of Income and Expenditure for 1942 were also considered and approved.

Membership.—Five applications for membership of the Institution were approved for submission for ballot by corporate members. In addition, five transfers to full membership and two applications for studentship were approved.

Meeting of Council in Manchester.—The Council resolved to accept the invitation of the President to hold its May meeting in Manchester.

Message from the A.G.A.

The Institution of Gas Engineers has received the following letter from the Managing Director of the American Gas Association in reply to a cable of good wishes sent by the Institution for the 23rd Annual General Meeting of the Association:

> "The cabled cordial greetings and best wishes of President Sir Frederick West and members of The Institution of Gas Engineers was read to our members assembled in general session at our annual meeting. The resulting spontaneous and unusual applause expressed volumes in sympathy and admiration as well as appreciation."

The Twentieth Annual Corporate Meeting of the Institution of Chemical Engineers will be held at the Connaught Rooms, Great Queen Street, London, W.C. 2, on Friday, March 27, at 11 a.m., when the President, Mr. C. S. Garland, will give his Address on "Chemical Engineering and Ceramics." There will be a luncheon following the meeting.

A **Booklet** has been published by Messrs. Sternol, Ltd. dealing with the cause and prevention of industrial dermatitis. It is claimed that the most effective way of protecting workers against the skin troubles common in industry is the use of Sternocleanse, which, if rubbed in before work begins, prevents the dirt, grease, oil, chemicals, dyes, &c., from penetrating the skin. This method has been used by many important industries with satisfaction. The makers, whose address is Grey Timbers, Westerham Road, Limpsfield, Oxted, Surrey, offer a trial supply.

Messrs. Robert Dempster & Sons, Ltd. (Elland and London) announce that as from April 13 they will relinquish their "alternative London Office at Knebworth and resume regular occupation at 16, Queen Anne's Gate, S.W. 1 (Whitehall 2661).

The fact that goods made of raw materials in short supply owing to war conditions are advertised in the "Journal" should not be taken as an indication that they are necessarily available for export.

TOWN GAS AND KINEMATIC VISCOSITY*

By ARTHUR COE

THERE are two outstanding facts to be observed relating to combustion phenomena. These are that the conditions of flow and the viscosity have never been taken into account.

It is obvious that gases cannot burn at a flame front until they reach it, and that they can only flow there. Also, as gases consist of molecules which are relatively small compared to the spaces between them, the reacting molecules must effect contact with one another when they reach the flame front before combustion can occur. That is, there is a secondary system of flow within the flame. Are these different kinds of flow?

If you take two cubes, one filled with gas and one a vacuum, and then connect the two, gases will diffuse or flow from one cube into the other. The same process occurs if one cube be a gasholder and the other several miles of pipe. That is, equalization of pressures as affected by diffusion and flow along a pipe is therefore directed diffusion. Hence, the fundamental difference between a gas at rest and a gas flowing along a pipe is that diffusion continues, but the direction and magnitude of the movements of the molecules are not the same in all directions. A gas thus flows along a pipe by virtue of the motions of its molecules. That is, the translatory motion of the gas as a whole is the sum of the translatory motions of the individual molecules in the direction of flow.

It follows from this that in measurements of gas flow we are concerned primarily with a change in the direction and magnitude of the molecular movements of the gas taken as a whole. This is usually expressed in terms of the energy absorbed in effecting the change in the orientation of the molecular motions to effect this, and measured as a resistance to flow.

In 1883 Osborne Reynolds discovered by experiment that the resistance to the flow of any fluid in a pipe is dependent upon its density, w, its absolute coefficient of viscosity, η, the velocity of flow, v, and the diameter of the pipe, d, these variables being correlated by the expression wvd/η. This is now known as Reynolds' criterion or Reynolds' constant, and may be represented thus:

$$\frac{wvd}{\eta}, \text{ or since kinematic viscosity } \nu = \frac{\eta}{w}, \text{ by } \frac{vd}{\nu}.$$

Reynolds formulated a law of resistance to flow upon the results of his experiments which showed that for any particular value of vd/ν or wvd/η which may be arrived at by any particular combination of the factors, v, d, w, and η, there is a definite value of R/wv^2.

It was not, however, until 1912 that the significance of this work began to be appreciated, and since then the experiments of Reynolds have been repeated and extended by Rayleigh, Stanton, and Pannell, and others. The results obtained are set out in the series of curves given in fig. 1. The value of the friction factor corresponding to a given value of Reynolds constant can only be obtained by reference to these curves. Kinematic viscosity has thus been incontrovertibly established as the property of gases which determines their rate of flow under given conditions.

Kinematic viscosity measures the rate at which the equalization of velocity goes on by the interchange of momentum between molecules. The distribution of molecules throughout the mass of a gas which accompanies this process is expressed as a coefficient of diffusion, and the relationship between the two, derived from the kinetic theory, is—

$$\gamma = 0.6479\ D, \text{ where } D \text{ is the coefficient of diffusion.}$$

We can therefore describe kinematic viscosity also as a criterion of the molecular motion or diffusion which occurs in gases at rest, and since flow is directed diffusion, we can regard Reynolds constant as a criterion of the diffusion which occurs in gases when flowing.

We can test these notions further by the use of Joule's concept that the diffusion of molecules in a gas at rest may be resolved into three components, which in the mean are of equal magnitude. The practical soundness of this concept is established beyond dispute, and it is interesting to note that the method used to obtain the mean speed of the individual molecules was made possible by it.

Applying this concept and resolving the movements of the molecules in the normal process of diffusion into three components, two of these will be affected by the confining walls of a pipe. The effect of the walls, however, is not to reduce or add to the molecular energy of the gas, but to change the direction of the molecules falling upon them and so limit the expansion which would otherwise occur. That is, diffusion is restricted within a given space, and, since doubling the diameter will double the area of the restricting surfaces, this effect will vary directly with the diameter, d.

The third component coincides with the line of flow. Diffusion in this line can therefore be effected by the velocity of mass flow, for if the rate of mass flow could be equivalent to the rate of diffusion as in a gas at rest, diffusion would in effect be restricted to the direction of flow. Doubling the velocity of flow, v, will clearly double this effect.

In other words, the resistance to the process of diffusion in a gas flowing in a pipe will vary as v and d or vd.

These factors will clearly affect the time required for equilibrium to be effected. For example, if d be doubled the molecules will take twice as long to diffuse from one wall to the other. The actual time taken will depend upon the rate at which the equalization of velocity is effected by the exchange of momentum between the molecules. If this rate be doubled, the time taken will be halved, so that the time factor in diffusion, and therefore the process of diffusion itself, will be affected directly by v and d and inversely by the rate of equalization of velocities, for which the coefficient is kinematic viscosity. Expressing these facts algebraically we have vd/ν as a criterion of the diffusion which occurs in gases when flowing. It has no dimensions, but is a measure of the change which occurs in the state of diffusion when a gas is flowing. Moreover, when a given value is obtained for this criterion by any possible combination of these factors it will obviously indicate precisely the same state of diffusion.

This expression is obviously identical with the criterion obtained experimentally by Reynolds, for which there has not previously been a rational explanation.

There is no time to develop fully the theory of diffusion-states which arises naturally from this discovery, beyond pointing out that it postulates that in streamline flow diffusion may be resolved into one direction only, when the resistance to flow will vary directly as the velocity of flow v; that at the lower and higher critical velocities, the state of diffusion may be resolved into two directions, when the resistance to flow will vary as v^2; and that in the middle of the S-bend of the Stanton curve the diffusion-state may be resolved into three components, when the resistance may be expected to vary as v^3. All of which is in agreement with the results of experiments and the fact that with streamline flow the state of the walls of the pipe has no effect upon the friction factor, one curve covering all conditions of surfaces. (By this theory diffusion in streamline flow may be resolved into one component parallel to the axis of the pipe.)

This theory of diffusion or flow-states also indicates that the roughness of the interior surfaces of a pipe will have no effect on the criterion of diffusion, but only upon the corresponding friction factor. In other words, for all flow-states, except streamline, the value of the friction factor depends upon two distinct factors, the diffusion-state, and a viscous drag which varies with the roughness of the interior surfaces. The effect of this viscous drag will be clearly proportionate to the criterion of diffusion, and its effect will be therefore to vary the value of the friction factor equivalent to a given value of Reynolds' constant with the degree of roughness of the confining walls for all states of flow except streamline. I am not aware that these two factors have been previously separated and defined.

The general expression for the mean volume rate of flow of a mixture under all conditions of flow through a horizontal pipe, in self-consistent units, when the pressure drop is sufficiently low to ignore the compressibility of the gas, is—

$$v = \sqrt{\frac{pd^2g}{8(R/wv^2)wL}}$$

For streamline flow this may be simplified to—

$$v = \frac{pd^2g}{32\eta L},$$

i.e., to the formula originally due to Poiseuille.

In self-consistent f.p.s. units—

v = the mean velocity of flow in feet per second.
d = the internal diameter of the pipe in feet.
L = the length of the pipe in feet.
η = the absolute viscosity in the f.p.s. unit (poises × 0.0672).
p = the pressure drop in pounds per square foot.
g = the acceleration due to gravity (32.2 ft. per sec.).
w = the density of the gas in pounds per cubic foot.
R/wv^2 = the friction factor of the Reynolds-Stanton law evaluated by reference to the constant, vd/ν, in self-consistent units, measured under the conditions of flow, and reference to the appropriate Stanton curve.

The volume rate of flow V_r in cubic feet per second is then—

$$V_r = \frac{pd^2g}{32\eta L} \times \frac{d^2}{4} = \frac{p\pi d^4 g}{128\eta L}$$

and the mass rate of flow in pounds per second M_r, when w is the weight in pounds of one cubic foot, and η/w is represented by ν (the kinematic viscosity), is—

$$M_r = \frac{p\pi d^4 g}{128\nu L}.$$

* Author's abstract of a Paper to the Scottish Junior Gas Association (Eastern District).

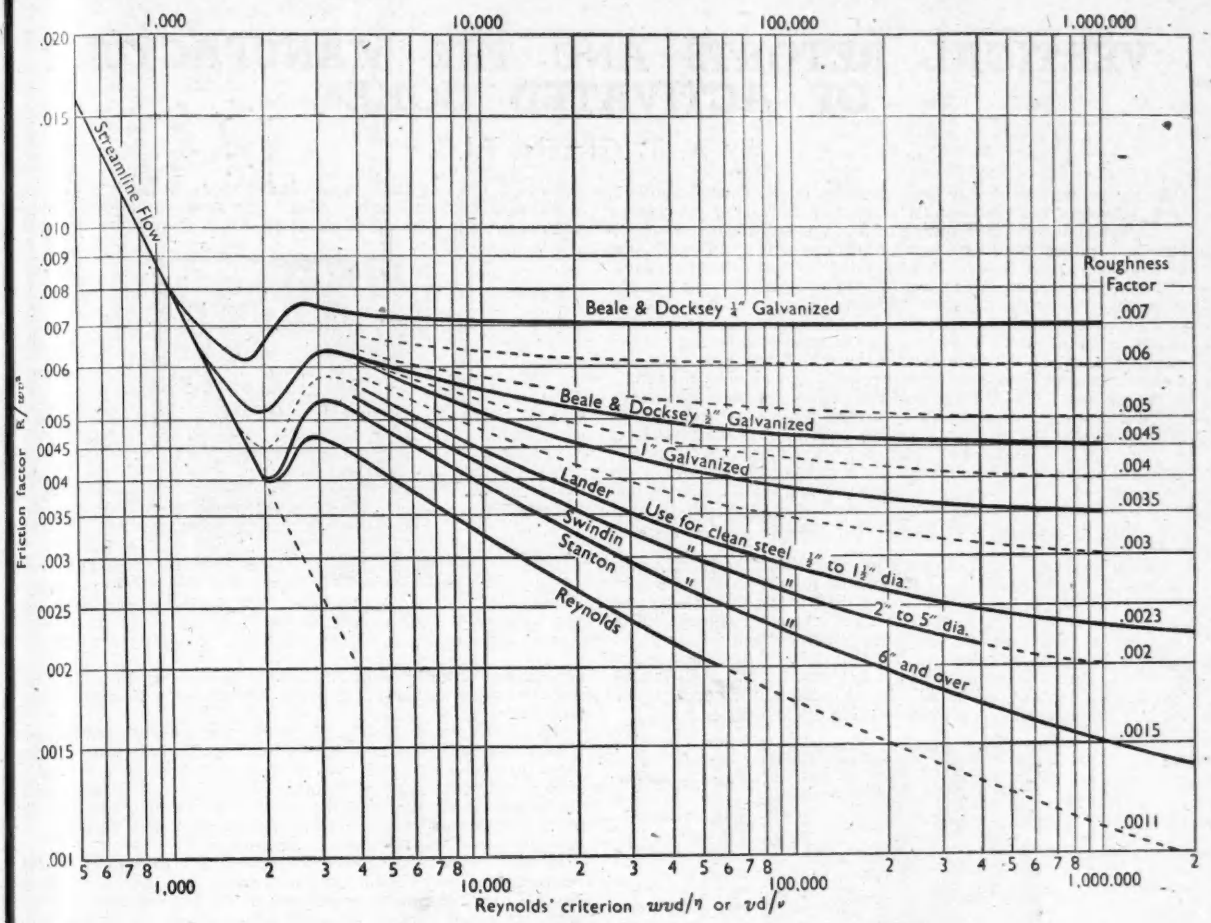


FIG. 1.

The mass rate of flow thus varies inversely as the kinematic viscosity.

It is useful to view Reynolds' criterion with the substitution of the expression for the calculation of v, when it will be observed that the length of the pipe as well as the diameter is taken into account.

It is also necessary to note the connexion between kinematic viscosity and pressure. Kinematic viscosity is a rate of interchange of momentum, and pressure may be defined as momentum which is transferred in unit time through unit area of any imaginary plane in a gas, Hence, the rate of transfer of momentum from one part of a gas to another in the equalization or maintenance of pressure depends upon kinematic viscosity. Note here that kinematic viscosity (absolute viscosity/density) must be calculated with reference to the absolute viscosity and density of a gas at the same temperature.

We can now consider the mechanism of the bunsen burner in terms of flow. In this view, the terminal pressure of the flow system is at the outer cone, and the initial pressure may be taken to be that at the throat or choke, or at any convenient point in the burner tube beyond this point, as the pressure changes through the burner itself are clearly directly related to one another. Fig. 2 shows the various parts of an atmospheric gas burner as referred to here, and fig. 3 supports the deduction that a point of initial pressure exists.

In short, the pressure drop which causes the mixture to flow to the flame front is that which occurs between the burner throat and the outer cone. But, before we can proceed further with this, it is necessary clearly to understand what takes place when air is entrained by the gas stream between the injector orifice and the point of initial pressure.

The term entrained is a very unfortunate one, for it tends to obscure the fundamental fact that the ultimate process by which the individual molecules of two or more different gases become mixed to produce a homogeneous mixture is solely that of diffusion. We know also from experience that the motions set up in a mixture by diffusion are very slow compared with those set up by mechanical actions, such as difference of pressure. So that if two gases at equal temperature and pressure be allowed to mix by diffusion, the heavier gas being below the lighter, the process will take a long time. But, if two gases or parts of the same gas at different pressures be connected, equalization of pressure takes place almost immediately.

The theory of diffusion or flow-states developed above postulates that kinematic viscosity is the criterion of diffusion in gases at rest, and that the criterion of the diffusion which occurs in flowing gases in a pipe or cylinder is vd/v. But for streamline flow this may be simplified to the kinematic viscosity.

(*To be continued*)

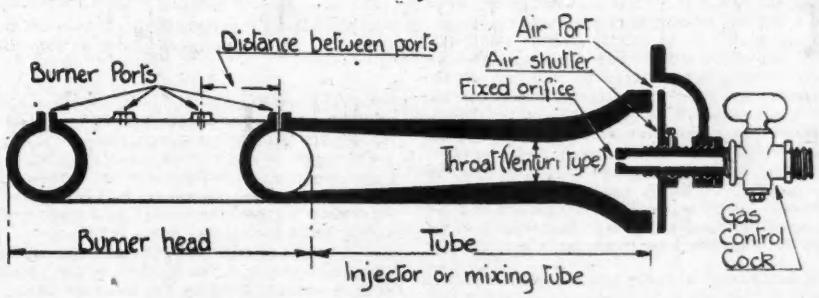


FIG. 2.

VERTICAL RETORTS AND THE MANUFACTURE OF ACTIVATED COKE*

By A. T. GREEN, F.I.C.

AN account has already been given by H. H. Thomas and P. J. Askey† of the experimental production of reactive gas coke by alkali-activation in a setting of four upwardly heated Woodall-Duckham vertical retorts. These formed one unit of an installation of 16 retorts at the Garston Works of the Liverpool Gas Company. The retorts were 26 ft. 7 in. in length by 74 in. by 10 in. at the top, and 82 in. by 18 in. at the bottom. The lower fireclay courses up to the sliding joint extended for about 5 ft. 9½ in. from the seating; the silica section extended for 13 ft. 9⅜ in., and the remaining 7 ft. at the top was of fireclay. For twelve months the retorts had been operating the activated coke process for the most part at temperatures of 1,025°C. at the top and 1,330°C. at the bottom. Two-stage heating was then introduced when the average temperatures were 1,080° to 1,100°C. at the top and 1,280° to 1,300°C. at the bottom. These temperatures may perhaps be considered as somewhat below normal. The retorts remained in operation for a further five months before being let down for inspection. The retorts were not new when the alkali activation process was started; the top firebrick courses were re-set, but the silica and lower firebrick sections were merely pointed after a previous working of 3½ years.

During the early period of operating the process, the charges were steamed at a rate which had been normal for the Company's coke product "Dryco." It was then found that, owing to the increased reactivity of the coke, the same steaming effect could be obtained with considerably less steam and consequently reduced ash release at the point of maximum temperature. The two-stage heating was adopted in order to lower the temperature and to spread the effect of steaming over a greater area of retort wall. In the opinion of the management the bulk of the erosion was caused during the first period.

FIG. 1.—*No. 2 Retort, Inner Corner, Side B, 5th, 6th, and 7th Courses above Sliding Joint.*

Reporting on the state of the refractory brickwork after 17 months' production of activated coke, while the retorts were still under fire, Thomas and Askey stated that the general condition was excellent except for two areas in each retort wall at the extremity of each major axis in the first few courses of the silica work. The following gives the results of an inspection when the retorts were cold. Fortunately, two adjacent retorts which had been used for carbonizing the same coals without alkali addition were also available for inspection and comparison.

General Condition of Retort Brickwork

Of the six retorts inspected, Nos. 1 to 4 had been used for the alkali process and Nos. 5 and 6 had had normal working.

In retort 2 the condition of the lower fireclay courses was good; there was some wearing down of the walls. The inner wall was worn fairly evenly, suggesting abrasive action. The main action on the brickwork was to be seen in the lower silica courses just above the sliding joint. Towards the inner wall the last 4 ft. of the B side (see fig. 3) showed considerable erosion and some holes through the wall had developed (fig. 1). The attack on the corresponding position on the A side was evident, but no holing had occurred. Similar actions had apparently occurred on the A and B sides at the same level towards the outer wall. There was some disintegration and dry roughening of the surface of the outer wall. At a higher level in the retort, about 12 ft. up, the slag attack on both the A and B sides continued, but was more pronounced towards the corners. The end walls were both reasonably good. The zone of noticeable attack continued up to a height of about 16 ft. In the top fireclay section

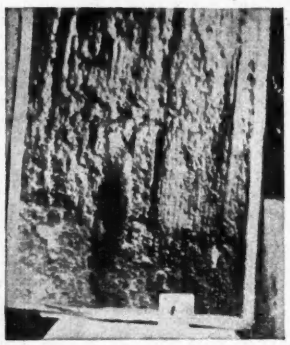


FIG. 2.—*No. 4 Retort, Inner Corner, Side B, 5th, 6th, and 7th Courses above Sliding Joint.*

considerable disintegration and pitting were observed. There was some flaking of the silica courses immediately below the upper fireclay section.

Retort 3 showed features similar to No. 2 in the erosion of the lower silica courses of the A and B sides towards the inner walls. Above these two zones the retort was in good condition up to the flaking zone in the upper silica brickwork. In this region flaking was most pronounced in the centre of the walls for about eight courses. The fireclay brickwork above showed considerable disintegration, but here the action was strongest in the corners.

In retort 4 repairs had commenced and some brickwork had already been removed. The condition was generally very similar to that of No. 3. Fig. 2 shows the appearance of the 5th, 6th and 7th course above the sliding joint on the inside corner of side B. The condition in the upper courses of the silica work and in the upper fireclay was slightly worse than in retort 3.

Retort 5 had not been used in the production of alkali-activated coke; nevertheless there was erosion and holing in the 7th silica course above the sliding joints on the inner A side and to a lesser degree on the B side in much the same positions as were noted with retorts Nos. 1 to 4. The slagging of the brickwork was, however, not so severe. In the upper portion of the retort, flaking of the silica and disintegration of the fireclay courses (possibly due to hydrocarbon action) was equally as severe as in the retorts making activated coke.

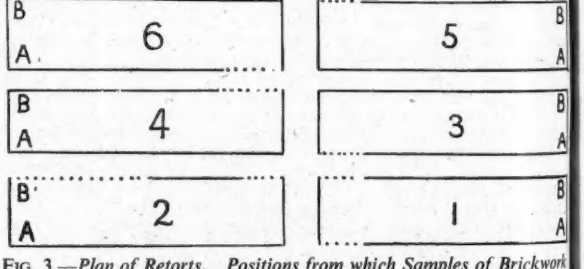


FIG. 3.—*Plan of Retorts. Positions from which Samples of Brickwork were taken shown as dotted lines.*

Retort 6 was in better condition than No. 5, and required very little patching before being put into service. The positions of erosion, spalling and disintegration were similar.

The minor axis measurements of the silica section of the six retorts in two planes given in Table I serves to indicate the general extent of the erosion and slag accretion that had occurred. It is apparent that the erosion is greater in retorts 1 to 4 than in retorts 5 and 6, and that it extended upwards for about eight courses from the sliding joint, and was more pronounced in the corners, especially towards the inner wall. The extent of the spalling in the upper portion of the silica work is also disclosed by the measurements. The measurements of the firebrick sections were fairly normal.

* From the 32nd Report of the Refractory Materials Joint Committee (Gas Research Board Communication No. 5).

† "GAS JOURNAL," 1940, **230**, 580.

TABLE I.—Minor Axis Measurements, in Inches.

Retort No.	1		2		3		4		5		6		Original.
Distance from inner wall, in.	17	33	17	33	17	33	49	65	17	33	17	33	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Course No. (from bottom):														
17 (end of fireclay)	17.8	17.6	17.8	17.7	17.9	17.7	17.8	17.9	18.1	17.9	17.9	17.7	18.0
18 (first silica)	18.5	18.0	18.7	18.1	18.4	17.9	18.1	18.3	17.8	17.6	17.9	17.6	18.0
20	19.0	18.1	19.0	18.4	19.0	18.0	18.2	18.6	17.9	17.6	18.1	17.5	18.0
22	19.0	17.6	19.2	18.4	19.2	17.9	17.8	18.4	18.1	17.5	18.1	17.4	18.0
24	18.2	17.4	18.6	17.9	18.4	17.8	17.4	17.9	17.9	17.6	17.8	17.4	17.9
26	17.4	17.0	17.8	17.3	17.8	17.4	16.9	17.2	17.5	17.3	17.4	17.2	17.5
28	16.6	16.6	17.0	16.8	17.3	17.1	16.7	16.9	16.9	16.7	17.1	16.9	17.1
30	16.3	16.3	16.5	16.2	16.8	16.7	16.4	16.5	16.6	16.7	16.8	16.7	16.7
38	15.3	15.2	15.1	15.1	15.4	15.3	15.3	15.4	15.3	15.3	15.4	15.7	15.0
40	15.4	14.4	14.8	14.8	15.1	15.0	15.1	15.1	14.9	15.0	15.1	15.2	14.6
42	14.9	14.6	14.5	14.6	14.7	14.8	14.9	14.9	14.7	14.8	14.7	14.9	14.2
45 (end of silica)	14.1	13.9	14.0	13.9	14.0	14.0	14.1	14.2	14.0	14.1	13.9	14.0	13.5

Analysis of Selected Samples

In order to determine more definitely the extent to which the additions of sodium and calcium carbonates had been responsible for the attack on the brickwork towards the bottom of the retort, sections of affected silica brickwork were removed without disturbing the sequence of the courses. From these large samples smaller samples were taken for anlysis. The positions where the brickwork was removed for examination are shown in plan in fig. 3.

A selection of the analytical data is given in Table II. The "surface layer" samples extended to a depth of about ¼ in. in the brick and the "under layer" samples were taken from the underlying ¼ in.

TABLE II.—Partial Analyses of Silica Brick Samples from Vertical Retorts Used in the Manufacture of Activated Coke.

Retorts.	Surface layer, %.			Under layer, %.		
	$Na_2O + K_2O$.	Fe_2O_3.	CaO.	$Na_2O + K_2O$.	Fe_2O_3.	CaO.
	2	3	4	5	6	7
Retort 1: Side A:						
Course 4	3.61	—	—	0.48	—	—
6	2.23	7.28	4.04	1.23	4.80	3.22
8	1.19	—	—	2.02	—	—
Side B:						
Course 5	2.65	6.40	2.85	2.42	3.58	2.23
6	2.65	—	—	2.00	—	—
8	2.36	—	—	1.49	—	—
Retort 2: Side B:						
(outer Course 4	3.18	—	—	2.57	—	—
corner) 5	1.33	5.09	3.10	1.43	1.44	2.01
7	2.96	3.25	2.91	0.83	1.25	2.07
(inner Course 4	3.94	1.56	2.85	1.59	1.56	2.85
corner) 5	4.14	5.19	3.13	1.71	—	—
6	7.04	13.94	7.92	2.03	7.93	4.92
7	2.48	—	—	0.98	—	—
Retort 3: Side A:						
Course 4	2.68	—	—	1.01	—	—
6	1.50	6.46	4.19	2.58	6.05	3.01
8	2.51	—	—	3.50	—	—
Retort 4: Side B:						
Course 4	1.44	—	—	2.50	—	—
6	1.75	5.59	6.45	2.04	4.09	3.03
8	1.54	—	—	1.75	—	—
Retort 5: Side B:						
Course 4	0.99	9.64	1.74	0.65	8.31	2.35
6	0.36	—	—	0.54	—	—
8	0.46	—	—	0.92	—	—
Retort 6: Side A:						
Course 5	1.11	7.89	1.92	0.58	9.12	2.03
	0.75	—	—	0.40	—	—

Discussion of Results

The analyses demonstrate that the attacked brickwork in those retorts which had been used for making activated coke definitely contained a higher percentage of soda and of lime than brickwork from similar positions in the retorts worked normally. On the other hand, retorts 5 and 6 showed a greater slagging by iron compounds than retorts 1 to 4. On the whole, the results support the visual observations that the tendency to erosion was somewhat greater in the retorts to which soda and lime additions had been made. In only one instance was any gross contamination by alkali found (Retort 2, inner corner, course 6). In general, the alkali contents ranged between 1 and 4%.

It is necessary, however, to direct attention to the possible effects on the producer and combustion chambers of alkali and lime present in the activated coke. In an examination of the effects of carbonizing salty coals in a vertical retort, carried out a few years ago, the ill-effects were noted more on the flue side of the retort wall, the differential action from the alkali retained in the coke being increased by the relatively low temperature of carbonization. In that investigation, also, notable quantities of sulphate were found to occur. In the present investigation sulphates have been detected in appreciable amount, for 2.24% and 0.80% SO_3 were found in the 5th and 6th course samples from retort 2, inner corner. Samples of glass and fused brickwork from retort 2, nostril flue, had respectively the following percentage analyses: SiO_2, 59.33; TiO_2, 0.56; Al_2O_3, 9.30; Fe_2O_3, 11.26; CaO, 15.04; MgO, 1.26; alkalis, 1.34; and SiO_2, 54.59; TiO_2, 1.22; Fe_2O_3, 5.76; Al_2O_3, 26.17; CaO, 7.16; MgO, 0.90; alkalis, 1.21. The fluxing oxides are iron oxide and lime and only small quantities of alkalis. Due to their volatility the alkali compounds may have become concentrated elsewhere in the flue system.

Conclusions

The visual inspection, the measurement made on the retorts after letting down, and the analyses of affected brickwork, all indicate the greater erosive effect on the retort walls of coal to which additions of sodium and calcium carbonates have been made for the purpose of activation of the coke. The deterioration was most marked in the corners in the lower silica courses. In the particular unit examined, and bearing in mind the previous working obtained from the retorts, the final condition of the brickwork was not unduly bad. It should be pointed out, however, that the temperatures of working were somewhat lower than is frequent practice.

THE FUTURE OF COKE*

By J. G. BENNETT,

Director, British Coal Utilization Research Association

(*Concluded from p. 363*)

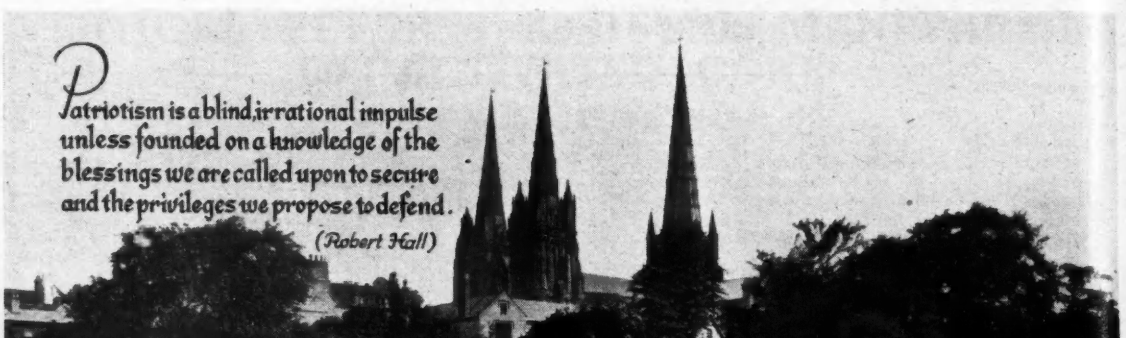
As regards size, so much good work has been done that I have no suggestion to offer except to express the hope that the same standard sizes will be adopted throughout the country both for gas and oven coke. It would be interesting to compare British and Continental practice in the matter of coke quality control. Noton[50] gave striking figures showing the extent to which the varieties of coke placed on the market had been reduced in Germany. Brabant[10] has described similar developments in Belgium.

It seems to me that we already have the requisite knowledge and experience to lay down standard specifications for cokes of a variety of grades and qualities which will not only meet all existing requirements, but greatly facilitate the new developments which we discussed in the preceding section. Any work on these lines should be undertaken by both branches of the carbonization industry and should, moreover, be made in consultation with the producers of the smokeless fuels of South Wales and in Scotland, which for many purposes are interchangeable with coke.

7. The Future of Coke

We have now to try to bring together the scattered fragments of our discussion to see whether they enable us to predict the future of coke and the lines of its probable development. We have not considered

* Paper presented at a Joint Meeting of the Coke Oven Manager's Association and the Institute of Fuel together with the Iron and Steel Institute and The Institution of Gas Engineers, Feb. 25.


Patriotism is a blind, irrational impulse unless founded on a knowledge of the blessings we are called upon to secure and the privileges we propose to defend.
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either the political or the commercial influences which will impinge on the more technical factors. The fuel and power policy of the country will to a great extent determine many of the issues. For example, a decision for or against large-scale gas grids will affect the amount of water gas to be made, and hence the amount of coke available for sale. Tariff policy as regards mineral traffic on the railways will largely determine whether surplus production from the coke-ovens can be sold in the South of England domestic market. Moreover, in any thoughts about the future, we have to recognize how profoundly the post-war situation may be influenced by the course of the war. Notwithstanding these limitations, I think it is still profitable to consider what in the national interest should be the future of coke.

I would say, first of all, that it is necessary to redouble, and more than redouble, all investigations into the control of coke quality and the possibility of producing satisfactory cokes from the widest possible range of our coal measures. This may be called one of the major problems in the wise utilization of our coal resources. The production of coke begins at the coal face. It is largely influenced by the treatment the coal receives at the pit. I have in mind, for example, the reduction of ash content to the economic minimum and even such further possibilities as sulphur elimination. Then there are questions of coal blending. We may ask ourselves whether it is possible to supply coke ovens and gas-works with blended coals of carefully controlled and constant characteristics. On the carbonization side great strides have been made in the control of coke strength, but the all-important property of reactivity is still, to a large extent, a matter of carbonization time and temperature. This remains the case, notwithstanding the influence that steam is known to have on the reactivity of coke and the possibilities of enhancing reactivity by pretreatment with lime, sodium carbonate, and other salts. The very close studies which have been made in the past of carbonization technique have mainly been directed to the production of gas, tar, and ammonium sulphate, and we have a long way to go before we have fully exploited the possibilities of coke quality control.

Then, on the utilization side, there are two main groups of questions. The first are commercial. They include the standardization of size and quality throughout the country, price regulation, provision of service to consumers, the adjustment of market as between the different branches of the carbonization industry, the equalization of seasonal demand by stocking programmes, and many other matters on which a concerted policy between all the different branches of the industry should work to the national benefit. The second group of questions concerns the technical utilization of coke. There are, on the one hand, great possibilities of improving the present-day appliances. No one can be fully satisfied, for example, with the present operation of gravity-fed coke boilers. These are too prone to clinker trouble to be regarded as the complete answer to the demand for an automatic central-heating system using solid fuel.

Then there are all the new developments which I have outlined. All these should be the subject of concerted action by the coal and carbonization industries. In my view, it would be a tragic mistake if we returned to the pre-war situation when the carbonization industries were considered in some way competitors or even opponents of the coal industry. No more ridiculous relation could exist as between the coal industry's largest individual customer and the carbonization industries' sole source of raw material. The production of coke is by far the most important manufacturing process in which coal is used. It is in the interests of the coal industry to encourage it in every possible way, for the technical possibilities of a manufactured fuel exceed those of a raw fuel in many important respects. On the marketing side, the carbonization industries will naturally retain their own independent organizations, but on the side of research and technical development there is no room for a policy of isolation.

To the question implied in the title of this Paper—whether coke has a future at all—I would reply that, far from thinking the days of manufactured solid fuels to be numbered, I believe that their great period is just beginning. It would benefit this country if all the interests concerned in the production and use of coke could pool their resources and bring us into a leading position in all these new developments.

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Gas Products Prices

The London Market Mar. 16.

There is very little movement in the prices of Coal Tar Products, as many of the usual markets are no longer available and pitch/creosote mixture as a fuel oil has taken their place.

Pitch is still a nominal market, but for such quantities as are being sold the price ranges between about 45s. and 50s. per ton. Creosote is about 5d. to 6d. per gallon. With regard to refined tar the price for next season has not yet been definitely fixed and it is expected that this will come under a Direction to be issued by the Coal Tar Controller. Pure toluole remains 2s. 5d. per gallon under the Ministry of Supply Toluene No. 2 Order. Pure benzole is about 1s. 10d., 95/160 solvent naphtha is 2s. 5d. to 2s. 9d. and 90/160 pyridine remains about 13s. 6d. per gallon. All the above prices are *ex* Makers' Works. Naphthalene prices are unchanged and are in accordance with the Control of Tar Order 1941. The Order refers to maximum prices, and the figure for refined crystal naphthalene in 2-cwt. bags and 4-ton lots is £23 per ton delivered.

The Provinces Mar. 16.

The average prices of gas-works products during the week were: Pitch and Crude Tar,* Toluole, naked, North, 1s. 10d. (controlled by the Control of Toluene No. 2 Order, July 5, which fixes the maximum price at which this material may be sold). Coal tar, crude naphtha, in bulk, North, 11d. to 1s. Solvent naphtha, naked, North, 1s. 9d. to 1s. 10d. Heavy naphtha, North, 1s. 9d. to 1s. 10d. Creosote, *ex* works, in bulk, North, liquid and salty, 4½d. to 4¾d.; Scotland, 4½d. to 4¾d.; low gravity, 4¼d. to 4½d. Fuel Grade, 4d. to 4¼d. Carbolic acid, 60's, 3s. 7½d. to 3s. 9d. Naphthalene, £15 to £20. Salts, drained, £6 to £6 10s.; whizzed 72°, £7 15s.; 78°, £9 5s. Anthracene prices fixed by Controller. Heavy oil: Unfiltered anthracene oil (min. gr. 1,080), 6d. to 6½d.; filtered heavy oil (min. gr. 1,080), 6½d. to 7d.; heavy anthracene oil gr. less than 1,080, 5¾d. to 6d.

*In regard to pitch and crude tar prices we would ask readers to refer to the editorial note on p. 396 of the "JOURNAL" for Sept. 10, 1941.

Tar Products in Scotland Mar. 14.

Prices remain firm. Refined tar 4¼d. to 5d. home and 4¼d. to 4½d. per gallon export. Creosote oil: Specification oil, 6d. to 6½d.; low gravity, 7d. to 7½d.; neutral oil, 6½d. to 6¾d. per gallon; all *ex* Works in bulk. Cresylic acid is in good call. Values are higher. Pale 99/100%, 5s. to 5s. 6d.; Pale 97/99%, 4s. 6d. to 5s.; Dark 97/99%, 4s. 3d. to 4s. 6d. per gallon; all *ex* Works in buyers' packages. Crude naphtha: 6½d. to 7d. Solvent naphtha: 90/160 grade, 2s. to 2s. 3d., and 90/190 Heavy Naphtha 1s. 9d. to 2s. per gallon. Pyridines: 90/160 grade 13s. and 90/140 grade 15s. per gallon.

Gas Stocks and Shares

Despite the dullness displayed in the majority of sections of the Stock Exchange last week, there was a distinctly brighter tone in the Gas Market. The volume of business was heavier than for the past few weeks and, as will be seen in the tables of price changes, with the exception of the fall in Gas Light Units and Oriental Stock, movements were all in an upward direction. Apart from *ex div.* markings, quotations in the Supplementary List have remained unchanged for the past fortnight.

The Directors of the British Gas Light Company, Ltd., have declared a final dividend of 3% on the ordinary stock of the Company, making a total of 6% for the year 1941, the same rate as for the previous year.

The following price changes were recorded during the week:

SUPPLEMENTARY LIST

Cheltenham Ord. (*x.d.*)	83—88	Mar. 9
Plymouth & Stonehouse 5 p.c. Deb. (*x.d.*)	95—100	,,

PROVINCIAL EXCHANGES

Bristol 5 p.c. max.	101½—103½	+2½
Liverpool Ord.	101—103	+1
Newcastle 3½ p.c. Deb.	86½—87½	+3½
Weston-Super-Mare 7½ p.c. Deb. ...	140—145	+5

OFFICIAL LIST

Alliance & Dublin Ord. (*x.d.*) ...	85—90	Mar. 9
Associated Gas & Water Undertakings 4 p.c. Pref.	12/—14/-	+2/-
Barnet Ord. (*x.d.*)	122—125	Mar. 9
Gas Light & Coke Units	13/—14/-	—/9d.
Ditto 3½ p.c. Red. Deb. (*x.d.*) ...	83—88	Mar. 9
Montevideo	65—70	+2
Oriental	95—105	—5
Severn Valley 4½ p.c. Pref. (*x.d.*) ...	16/—18/-	Mar. 9
South Suburban Ord.	73—78	+2
Ditto 5 p.c. Deb.	101—107	+1
Swansea 5½ p.c. Red. Pref.	93—98	+5
Tottenham Ord.	82—87	+2
United Kingdom 4½ p.c. 1st Pref. ...	15/6—17/6	+-/6d.
Ditto 4 p.c. 1st Pref.	15/6—17/6	+-/6d.
Wandsworth 4 p.c. Pref.	72—77	+2

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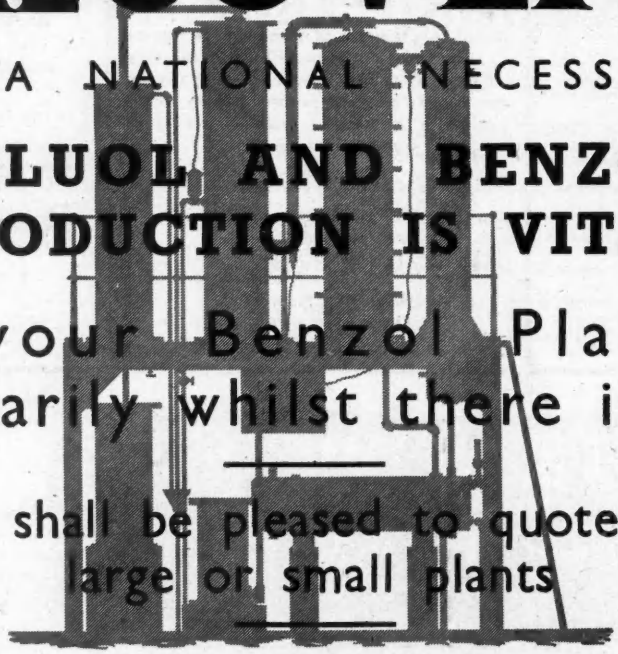

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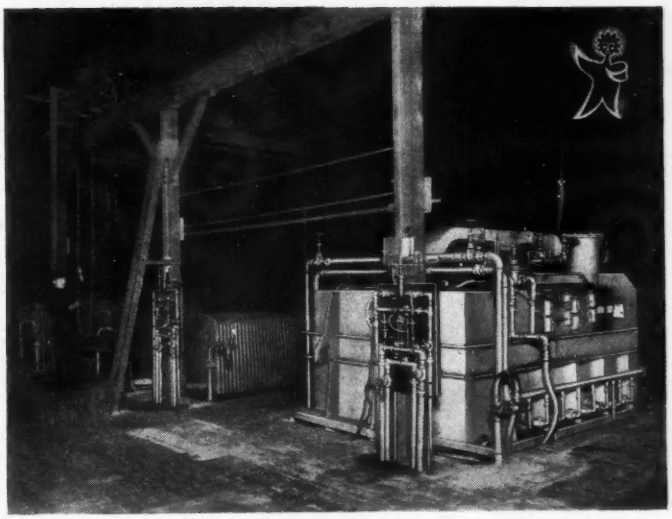
GAS FIRED BRIGHT ANNEALING BY BIRLEC

The furnace shown above is installed in a large Midlands rolling mill.

The installation comprises four hearths on which the charges (consisting of coiled steel strip and sheet) are laid. The charging space for each hearth is approximately 6′ x 2′ x 2′ 6″.

Each hearth is provided with a gas tight removable cover which encloses the charge, and in which an artificial atmosphere is established in order to prevent oxidation of the material being annealed. A movable heating chamber can be lowered over any one of the hearths.

The furnace is heated by burners of the *radiant block type*, recently made available in this country by BIRLEC, and designed to give rapid and uniform heating of the charge. Circulating fans are fitted and the closeness of the temperature control as measured on the charge itself is within ± 5° C.



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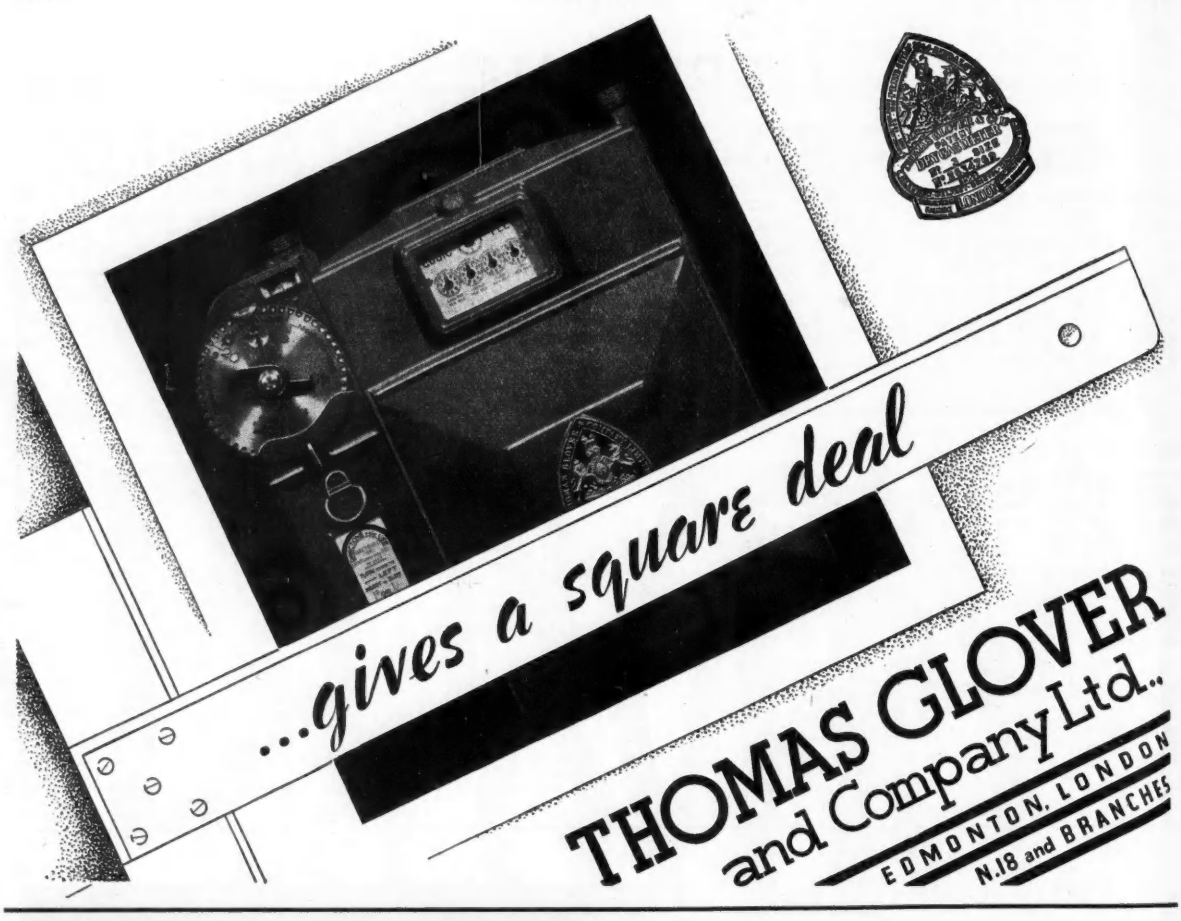
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